PART 4

GENERAL WORKMANSHIP, MATERIAL AND DESIGN REQUIREMENTS FOR PLANT

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PART 4

GENERAL WORKMANSHIP, MATERIAL AND DESIGN REQUIREMENTS FOR PLANT

4.1 Introduction

This part of the Employer's requirements sets out the standards of materials, workmanship and design to be used by the Contractor for Plant. Reference to any specific material or equipment does not necessarily imply that such material or equipment is to be included in the Works.

All Plant used for the Works shall, unless otherwise specified, comply with the provisions of this part.

The names of the manufacturers of materials and equipment proposed for incorporation in the Works together with performance, capacities, certified test reports and other significant information pertaining to the same, shall be furnished when requested for consideration by the Engineer, who shall have power to reject any parts which in his opinion are unsatisfactory or not in compliance with the Specifications and such parts shall be replaced by the Contractor at no extra cost to the Employer.

4.2 Compliance with Standards

The British Standard specifications shall refer to the latest issue or revision of those standards as issued by the British Standards Institution of 2 Park Street, London W1 and the Indian Standard Specifications as issued by the Bureau of Indian Standards; Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110 001 and ASTM standards as issued by the American Society for Testing and Materials, 1916, Race Street, Philadelphia, PA, 19103, U.S.A and ANSI standards as issued by the American National Institute, 1430, Broadway, New York, NY 10018, U.S.A. Equipment conforming to other national or international standards shall be at least equivalent to those specified and shall be subject to approval by the Engineer. Full details of the difference shall be supplied by the Contractor.

Where the design or choice of materials of plants is affected by the Factory Acts, then the materials and plant supplied shall comply with all relevant sections of those Acts even though no particular reference may be made in this Specification.

The Contractor shall obtain at least one copy of each IS, JIS, BS or other approved standards or reference material which are referred to in the Specification and a copy of all other standards which apply to materials which are being supplied to, or workmanship executed on the works. These standards and reference material shall be supplied to the Employer's Representative within 90 days of the commencement date and will be available to the Contractor at all reasonable times.

4.3 Materials General

All materials incorporated in the works shall be the most suitable for the duty concerned and shall be new and of first class commercial quality, free from imperfections and selected for long life and minimum maintenance.

All submerged (in contact with water, sludge, and wastewater) moving parts or the faces etc. of the Plant, or the pins and spindles, etc., shall be of corrosion resistant metals and all submerged fasteners, nuts and bolts shall be of SS316L. All parts in direct contact with various chemicals, shall be completely resistant to corrosion, or abrasion by these chemicals, and shall also maintain their properties without ageing due to the passage of time, exposure to light or any other cause. Where Mild steel is specified for submerged parts, polyurethane coating shall protect the metal.

Where “stainless steel" is specified or used, it shall have resistance to atmospheric corrosion not less than that provided by Stainless Steel ASTM A 276 Gr. 410 for forgings and BS EN 10293:2015, Grade 410-C-21 for castings. Particular attention shall be made to the prevention of seizure by fretting where two corrosion resistant metals are in contact, by the selection of materials of suitable relative hardness and surface finish and the application of lubricants. Where bronze is specified or used, it shall be zinc free, to BS EN 1982:2017.

Particular attention shall be paid to the prevention of corrosion due to the close proximity of dissimilar metals. Where it is necessary to use dissimilar metals in contact, these shall be selected so that the bimetallic corrosion is as low as possible. The publication by H. M. Stationery Office (in the U.K.) entitled “Corrosion and its Prevention at bimetallic Contacts" shall be used as a guide.

4.4 Workmanship General

Workmanship and general finish shall be of first class commercial quality and in accordance with best workshop practice and shall provide what is generally recognised as waterworks finish as defined elsewhere.

All similar items of plant and their component parts shall be completely interchangeable. Spare parts shall be manufactured from the same materials as the originals and shall fit all similar items of plant. Machining fits on renewable parts shall be accurate and to specified tolerances so that replacements made to manufacturer's drawings may be readily installed.

All equipment shall operate without excessive vibration and with minimum of noise. All revolving parts shall be dynamically balanced so that when running at all operating speeds and any load up to the maximum there shall be no vibration due to lack of balance.

All parts which can be worn or damaged by dust shall be totally enclosed in dust proof housings.

Dynamic balancing of rotary components shall be to the relevant standards. All bearings shall have L-10 rating life of minimum 40,000 hours.

All instruments used for the works whether for permanent installation or for checks/inspection at the Manufacturer's works or for checks/inspection at site shall be calibrated using standard reference instruments from institutions recognised by the Government such as "Institute for Design of Electrical Measuring Instruments (IDEMI), Mumbai.

All outdoor instruments shall be provided with locked, galvanised metallic enclosures of 2 mm thickness, suitably painted.

4.5 Design Life

All materials and equipment shall be designed for long life and shall be suitable for continuous 24 hour per days operation for prolonged periods with a minimum of maintenance and the Contractor may be called upon to demonstrate this for any component either by the service record of similar equipment elsewhere or by records of extensive type tests.

Routine maintenance and repair shall as far as possible, not require the services of highly skilled personnel.

Except for consumable items such as rubber bushings, gland packings, carbon brushes etc. which normally require replacement more frequently, no part subject to wear shall have a life from new to replacement or repair of less than three years of continuous normal operation and where major dismantling is required to replace a part, such life shall be not less than twenty years.

4.6 Welding

In all cases where welds are liable to be highly stressed, the Contractor shall supply to the Engineer before fabrication commences detailed drawings of all welds and weld preparations proposed. No such welding shall be carried out before the Engineer has signified his approval of the details proposed. No alteration shall be made to any previously approved detail of weld preparation without prior approval of the Engineer.

Welding shall comply with BS EN 1011-1: 2009.

Approval of welding procedures shall be as per BS EN ISO 15614: 2017. Welders shall be qualified to ISO 9606-1: 2017. All aspects of fabrication and examination procedures including pre/post-heating treatment, electrodes, non-destructive Tests (NDT) shall be subject to approval of the Engineer.

Following codes shall apply for the NDTs:

BS EN ISO 17636-2:2013:	Radiography;
BS EN ISO 17640:2010:	Ultrasonic Test;
BS EN ISO 9934-1:2016:	Magnetic Particle Test;
BS EN ISO 3452-1: 2021:	Penetrant Test.

4.7 Castings

All cast iron shall be of standard grey close-grained quality to BS EN 1561: 2011/IS 210 Grade 220 or better. The structure of the castings shall be homogeneous and free from non-metallic inclusions and other injurious defects. All surfaces of castings which are not machined shall be smooth and shall be carefully fettled to remove all foundry irregularities.

Minor defects not exceeding 12.5 per cent of total metal thickness and which will not ultimately affect the strength and serviceability of the casting may be repaired by approved welding techniques. The

Engineer shall be notified of larger defects and no repair welding of such defects shall be carried out without prior approval.

If the removal of metal for repair should reduce the stress-resisting cross-section of the casting by 25 percent, or to such an extent that the computed stress in the remaining metal exceeds the allowable stress by more than 25 per cent, then that casting may be rejected. Castings repaired by welding for major defects shall be stress relieved after such welding.

Non-destructive tests will be required for any casting containing defects whose extent cannot otherwise be judged, or to determine that repair welds have been properly made.

4.8 Instrument Components

Iron and steel parts shall in general be painted or galvanised as appropriate in accordance with the Specification. Indoor parts may alternatively have chromium or copper-nickel plating or other approved protective finish.

Small iron and steel parts (other than stainless steel) of all instruments and electrical equipment, the poles of electro-magnets and the metal parts of relays and mechanisms shall be chromium or copper-nickel plated or have some other approved finish to prevent rust Cores, etc., which are built up of laminations or cannot for any other reason be antirust treated, shall have all exposed parts thoroughly cleaned and heavily enamelled, lacquered or compounded.

4.9 Safeguarding of Machinery

The Contractor shall ensure that all designs and equipment for which he is responsible are safe. Nothing in this Requirement shall remove the Contractors obligation from drawing the attention of the Engineer to any feature of the Works, which is not consistent with safety, or to prevent him making proposals for incorporating equipment or designs which would increase the safety of the Plant.

The installation layout and plant design shall not allow any item of plant to be so positioned that danger to operating personnel could arise during normal operation and maintenance. Particular attention shall be paid to the position of hot pipes, air vents and rotating machinery.

All rotating shafts, couplings, gears, flywheels, belt drives or other moving parts shall be fully guarded. Guards shall be designed to provide ready access to bearings, grease points, thermometer sockets and other check points and to allow safe routine observation and servicing to be executed without the need to dismantle any part of their structure.

4.10 Rating Plates, Nameplates and Labels

All equipment, apparatus and Plant shall be clearly labelled or fitted with nameplates and rating plates generally as follows:

4.10.1 Indoor Type Labels

(a) Labels for the outside of equipment shall be of a rigid type laminated and engraved plastic material, with black block capitals on a white background. The labels shall be fixed by non-rusting screws, or similar approved fixing device.

(b) Labelling inside equipment shall be as above except that a flexible self-adhesive type labelling may be used if suitable for the ambient temperatures and if not less than 12 mm in width.

4.10.2 Weather proof Labels

These labels may be vitreous enamelled or brass. Plastic labels will not be accepted unless proof can be given that the labels can withstand the environmental conditions found at Site.

Vitreous enamelled labels shall be secured by brass or non-rusting roundhead screws, with brass and fibre washers in contact with the enamel front and back to prevent damage.

4.10.3 Name and Rating Plates

Each main and auxiliary item of Plant shall have permanently attached to it in a conspicuous position a nameplate and a rating plate. Upon these shall be engraved the manufacturer's name, type and serial number of Plant, details of the loading and duty at which the item of Plant has been designed to operate, and such diagrams as may be required by the Engineer. All indicating and operating devices shall have securely attached to them or marked upon them designation as to their function and proper manner of use. Provision shall be made to incorporate descriptive numbering codes as indicated on the Record Drawings. Details of proposed plates, labels and inscriptions shall be submitted to the Engineer for approval before manufacture.

4.11 Lubrication

A complete schedule of recommended oils and other lubricants shall be furnished by the contractor. The number of different types of lubricants shall be kept to a minimum. The schedule and the name of the supplier of the lubricants shall be submitted to the Engineer for approval before incorporation in the instruction manuals. In the case of grease lubricated roller type bearing for electric motors lithium, base grease is preferred.

Where lubrication is effected by means of grease, preference shall be given to a pressure system which does not require frequent adjustment of recharging. Frequent, for this purpose means more than once a week and grease systems having shorter periods between greasing should be avoided. Where necessary for accessibility grease nipples shall be placed at the end of the extension piping, and, when a number of such points can be grouped conveniently, the nipples shall be brought to a common place mounted in a convenient position. Button head type nipples shall be used for normal grease and all grease nipples shall be of the same size and type for every part of the Plant. Arrangements shall be provided to prevent bearings being overfilled with either grease or oil.

Where more than one special grease is required a grease gun for each special type shall be supplied and permanently labelled.

Oil lubricated bearings shall be provided with an oil reservoir capable of automatically maintaining the correct oil level within the bearings. It must not be necessary to shut down the pump in order to see the oil level or to add oil to the bearings.

Oil sumps shall be fitted with oil level indicators of the sight glass type, or where this is not practicable, with dipsticks. The indicators shall show the level at all temperatures likely to be experienced in service. The normal, maximum and minimum levels at 20°C shall be clearly visible in the sight glass type from the normal access floor to the particular item of plant, and they shall be easily dismantled for cleaning.

All sight glasses shall be firmly held and enclosed in metal protection in such manner that they cannot be accidentally dislodged.

All lubrication systems shall be designed so as not to present a fire hazard and particular care shall be taken to prevent leakage of lubricants and to avoid leaking lubricants coming into contact with any electrical equipment, heated surfaces or another potential source of fire.

The Contractor shall supply flushing oil for each lubrication system when an item of plant is ready for preliminary running and a sufficient quantity of the approved lubricants for setting to work and for the commercial operation of the Plant for two years after the Taking over Certificate has been issued.

4.12 Initial Charges of Oil and Grease, etc.

The initial charges of oil, grease, electrolyte and similar materials necessary for the correct setting to work and operation of the Plant shall be included in the appropriate Plant item.

4.13 Non-metallic Materials

Fabrics, cork, paper and similar materials which are not subsequently to be protected by impregnation shall be treated, with an approved fungicide. Sleeving and fabrics treated with linseed oil varnish will not be permitted.

The use of organic materials shall be avoided as far as possible but where these have to be used they shall be treated to make them fire resistant and non-flame propagating.

The use of wood shall be avoided as far as possible. If used, woodwork shall be thoroughly seasoned teak or other approved hardwood which is resistant to fungal decay and other blemishes. All woodwork shall be treated to protect it against damage by fire, moisture, fungus, vermin, insect, bacteria or chemical attack, unless it is naturally resistant to all these. All joints in woodwork shall be dovetailed or tongued and pinned. Metal fittings on wood shall be of non-ferrous material. Adhesives shall be specially selected to ensure the use of types which are impervious to moisture and fungus growth. Synthetic resin cement shall be used for joining wood.

4.14 Engineering Hardware

Nuts, bolts, studs and washers for incorporation in the Works shall conform to the requirements of the appropriate British or other approved standard. Nuts and bolts for pressure fittings shall be of the best quality steel machined on the shank and under the head and nut.

Bolts shall be of such a length that one thread shall show through the nut when in the fully tightened condition.

Fitted bolts shall be a light driving fit in the reamed holes they occupy, shall have the screwed portion of such a diameter that it will not be damaged in driving and shall be marked in a conspicuous position to ensure correct assembly at site.

Washers, locking devices and anti-vibration fittings shall be provided where necessary to ensure that no bending stress is caused in the bolt.

Where there is a risk of corrosion, bolts and studs shall be designed so that the maximum stress in the bolt does not exceed half the yield stress of the material under all conditions.

All submerged hardware Nuts, bolts, studs, washers, Fasteners shall be SS316L material.

All bolts, nuts and screws which are subject to frequent adjustment or removal in the course of maintenance and repair shall be made of nickel-bearing stainless steel.

The Contractor shall supply all holding down, alignment and levelling bolts complete with anchorages, nuts, washers and packings required to attach the Plant to its foundation, and all bedplates, frames and other structural parts necessary to spread the loads transmitted by the Plant to concrete foundations without exceeding the design stresses.

Unless otherwise necessary to meet special requirements all thread shall be of preferred metric sizes with standard coarse threads.

ISO metric black hexagon bolts, nuts and screws shall comply with SII 0589-81, or ISO 885:2000, ISO 888:2018, ISO 898-1 and -2: 2013.

ISO metric precision hexagon bolts, nuts and screws shall comply with ISO 272:1982, ISO 4759-1:2000, ISO 885:2000, ISO 888:2018, ISO 898-1 and -2:2018 or ASTM F-593, ASTM F-468 M, strength grade 8.8.

The dimensions of ISO metric countersunk head bolts screws, and hexagon nuts shall comply with ISO 225:2010, or ISO 888:2018, ISO 898-I.

Plain steel washers for use with ISO metric bolts shall comply with ISO 887:2006 or ASTM F-844.

Taper steel washers shall comply with ASTM F-844 and ASTM F-436.

4.15 Instruments

Unless otherwise specified, any indicating and recording instruments supplied under the Contract shall be approved by the Engineer. They shall be flush-mounted pattern with dust- and moisture-proof covers

and shall be suitable for the environment in which they are installed. Where hinged covers are necessary, they shall be provided with locks.

Indicating instruments shall be of the dial type and shall be provided with a readily accessible zero adjustment.

Dials in general shall be white with black markings and not subject to fading. Scales shall be of such material that no peeling or discoloration will take place with age under humid conditions.

Motor ammeters shall be capable of withstanding the starting current and shall have a compressed overload scale.

Steel screws, when used, shall be zinc, cadmium or chromium-plated, or where plating is not possible due to tolerance limitations, shall be of stainless steel. Instrument screws (except those forming part of a magnetic circuit) shall be of brass or bronze. Springs shall be non-rusting materials, e.g. phosphor bronze or nickel silver, as far as possible. Pivots and other parts for which non-ferrous material is unsuitable shall be of stainless steel.

Pressure gauges shall be not less that 150 mm diameter unless otherwise approved. The internal components shall be of stainless steel, bronze or some other corrosion resistant material other than aluminium. The gauges may be mounted directly on the pipework or side by side on a board or panel. Each pressure gauge shall be fitted with a stopcock immediately adjacent to the gauge, and all pressure gauge piping shall be fitted with an isolating valve at each point of connection to the main system. Where pressure gauges are mounted on panels, the isolating valve shall be suitable for the connection of a test gauge. Stopcocks of gauges shall be clearly identified by means of separate labels of approved type and lettering.

All fixed pipes below 25 mm nominal bore shall be compression jointed heavy gauge copper where this material is suitable. In other cases, pipe materials are to be approved by the Engineer. All pressure gauges shall be fitted with an air release cock and hydraulic pressure snubbers to protect them against shock pressures.

4.16 Noise and Vibration

The noise level produced by any equipment like pump sets, compressor sets and blower sets shall not exceed 85 dBA measured at a distance of 1.86 m from the outline of the equipment. At the time of operation, the mechanical vibration shall not exceed the limits given below, at recommended points of measurement as per ISO 2372-1974 with Amendment 1-1983.

Equipment	Velocity of Vibration mm/sec
All rotating equipment not having reciprocating parts with motor KW less than or equal to 15 KW	1.12*
All rotating equipment not having reciprocating parts with motor KW more than 15 KW and less than or equal to 75 KW	1.8*

All rotating equipment not having reciprocating parts with motor KW greater than 75 KW	2.8*

Note: * Values shall be as per latest version of ISO code

4.17 Piping and Equipment Layout

In general all pipes and fittings shall be steel or ductile iron with flanges to BS EN 1092-1 & 2.

Where steel and cast flanges are mated together, the steel flange shall be machined over its full face, after welding to respective pipe is completed.

Flexible joints shall be provided to facilitate installation and removal and/or differential movement of plant. Where required, flexible joints shall be provided with tie bolts or other means to transfer longitudinal thrust along the pipework as a whole.

The pipework shall be laid out and designed such as to facilitate its erection, painting in situ, dismantling of any section for maintenance and to give a constant and uniform flow of working fluid with a minimum loss in head. Where steel pipework is used the number of flanges is to be kept to a minimum with the size of each unit of pipework determined by the ease of handling, installation and general appearance of the completed pipe system. Positions of flanges shall take into account any necessary concrete pipe supports or thrust blocks.

Facilities shall be provided for draining and venting of the pipe system. Where a pipe passes through a wall, retaining wall or is subject to thrust it shall incorporate a puddle flange which shall conform to the dimensions stated in BS EN 1092-1 but remain undrilled.

Unless otherwise specified, nuts, bolts and washers for pipework shall conform to the requirements of BS EN 1092-1.

Bolts shall be of sufficient length that one thread shall show through the nut when in the fully tightened condition.

4.18 Gaskets and Joint Rings

Joint rings shall be manufactured to conform with BS 7874:1998, BS EN 681-1:2000, BS EN 681-2:2000, BS EN 682:2002 and shall be of chloroprene rubber or other approved synthetic material suitable for temperatures up to 80^{o}C.

Joints shall be made in accordance with manufacturer's instructions or as specified herein.

Until immediately required for incorporation in a joint, each rubber ring or gasket shall be stored in the dark free from the deleterious effects of heat or cold, and kept flat so as to prevent any part of the rubber being in tension.

Only lubricants recommended by the manufacturer shall be used in connection with rubber rings and these lubricants shall not contain any constituent soluble in water of the quality stated in the Requirements, shall be suitable for the climatic conditions at the Site and shall contain an approved bactericide.

After cleaning the flanges, the gaskets shall be fitted smoothly to the flange and the joint made by tightening the nuts to finger pressure first. Thereafter the final tightening of the nuts shall be made by gradually and evenly tightening bolts in diametrically opposite positions using standard spanners.

Graphite grease shall be applied to the threads of bolts before joints are made.

4.19 Steelwork

Any small areas of chequer plating or similar covering that are necessary to cover gaps between items of Plant and the surrounding structure, and any access ladders, platforms and handrails that must be attached to items of Plant to facilitate operation, inspection or maintenance, shall be supplied and erected by the Contractor.

The Contractor shall include in his Contract for providing adequate means of access to all hand wheels, sight glasses, gauges, lubrication points and any other items to which access is necessary for routine maintenance.

Handrails shall consist of 304 grade Stainless steel and rails of 14 gauge pipes.

Chequer plating shall be of `Durbar' or other non-slip pattern, not less than 6.0 mm thick (exclusive of pattern) and hot dipped galvanised after fabrication in accordance with BS EN ISO 1461: 2009.

4.20 Spare parts

The Contractor shall also supply the details of recommended spare parts and quantity required for the continuous operation of the Works for minimum period of 5 years as detailed Price Schedule. The cost of spare parts shall not be taken for evaluation. It shall not be binding on the Employer to buy any/part of the spare parts recommended by the contractor. The spare parts required shall be decided prior to Award of contract or during the execution of the contract, which shall be binding on the contractor.

All spare parts shall be new, unused and strictly interchangeable with the parts for which they are intended to be replacements and shall be treated and packed for long storage under the climatic conditions prevailing at the site. Each spare part shall be clearly marked or labelled on the outside of its packing with its description and purpose, and when more than one spare is packed in a single case or other container, a general description of its contents shall be shown on the outside of such case or container and a detailed list enclosed. All cases, containers and other packages shall be marked and numbered in an approved manner for purposes of identification.

All cases, containers or other packages are liable to be opened for such examination as the Engineer may require and packings shall be designed to facilitate opening and thereafter repacking.

"Spares, accompanied by technical details/leaflets etc., shall be delivered to site before the start of commissioning tests. Spare parts shall be indicated in the assembly drawings of respective plant items with clear details of part numbers. Contractor shall also furnish the manufacturers recommendations on spares for respective plant items."

4.21 Tools and test Equipment

The contractor shall supply the details of recommended special tools and test equipment required to enable any erection, dismantling or testing to be carried out on any part of the Plant, whether of an electrical, mechanical or any other nature during the life of the Plant and shall be listed in the Price Schedule. The cost of Tools and Test equipment shall not be taken for evaluation. It shall not be binding on the Employer to buy any/part of the tools and test equipment recommended by the contractor. The tools and testing equipment required shall be decided prior to award of contract or during the execution of the contract, which shall be binding on the contractor.

The tools and test equipment shall not be used for the erection of the Plant and except that the Engineer may call upon the Contractor to demonstrate their use or effectiveness, they must be handed over to the Employer in a completely new and unused condition. Should the Contractor require any such tools and test equipment at the site during erection, he shall provide his own.

The tools for each different type of equipment shall be contained in a suitable box clearly marked or labelled with its description. Each tool shall be identified and a list of tools shall be affixed to the inside of the box lid. Each set of tools shall be supplied with the equipment with which it is associated.

The test equipment shall include only special purpose items essential to the testing or recalibration of related items of Plant.

The tools provided shall include clamps, wrenches, lifting lugs, grease guns, gauges test rigs, jigs or extractors which may be required for the life of Plant. All tools and test equipment shall be clearly detailed with size/capacity etc.

4.22 Protection and Packaging for Transportation

Before any Plant is despatched from a manufacturer's works it shall be properly prepared and packed.

Prior to despatch all Plant shall be adequately protected by painting or by other approved means for the whole period of, transit storages and erection, against corrosion and incidental damage, including the effects of vermin, sunlight, rain, high temperatures and humid atmospheres. The Contractor shall be held responsible for the Plant being so packed and/or protected as to ensure that it reaches the site intact and undamaged. The Plant shall be packed to withstand rough handling in transit and all packages shall be suitable for storage including possible delays in transit.

The Contractor shall be deemed to have included in the Schedule of Prices for all materials and packing cases necessary for the safe package, conveyance and delivery of the Plant.

The flanges of pipes, valves and fittings shall be protected by wooden discs attached by means of service bolts (which shall not be used at Site) or by other approved means. The sleeves and flanges of flexible couplings shall be bundled by wire. Cases containing rubber rings, bolts and other small items shall not normally weigh more that 500 kg gross.

No one package or bundle shall contain items of Plant intended for incorporation in more than one section of the Works. All items of Plant shall be clearly marked for identification against the packing list.

Every crate or package shall contain a packing list in a waterproof envelope. A duplicate copy of the packing list shall be sent by post to the Engineer at Site.

All crates, packages, etc., shall be clearly marked with a waterproof material to show the weight, and where the slings should be attached, and shall also have an indelible identification mark relating them to the packing lists.

End of Part 4